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THE ORIGIN OF WORLDS.

Kant's Cosmogony as in his Essay on the Retardation of the Rotation of the Earth, and his Natural History and Theory of the Heavens. With introduction, appendices, and a portrait of Thomas Wright of Durham. Edited and translated by W. Hastie, D.D., Professor of Divinity, University of Glasgow. Pp. cix + 205. (Glasgow: James Maclehose and Sons, 1900.)

IN this work Prof. Hastie has not only given us a very readable book, but has written an important chapter in the history of astronomy. His main object is to make us recognise in Kant a profound genius, and to give us reasons for this appreciation. The author was well advised, for Kant, in the domain of natural science, enjoys a somewhat nebulous reputation. Few would care to say with exactness what particular view Kant supported concerning the origin of the cosmos, to what extent he was assisted by earlier writers, or how much of his work has been approved by later physicists. It was inevitable that the work of Laplace, appearing at a later date and supported by a renown won by his successful solution of problems connected with celestial mechanics, should occupy a position of wider acknowledgment and receive the assent of those who, unable to add any support or offer effective criticism to his theory, were content to rely upon his deservedly high reputation. Thus it has come about that more than one writer has owed his knowledge of Kant to very second-hand sources, and while only very imperfectly apprehending the points of difference in the systems suggested by the two philosophers, has allowed the later to eclipse and supplant the work of the earlier writer. Perhaps it is not too much to say that until Prof. Newcomb's "Popular Astronomy" appeared, no intelligent comparison between the theories of Kant and Laplace could be found in any popular work written in English. Prof. Hastie has, however, removed any difficulty that any one might experience in endeavouring to master Kant's views at first hand, and there is no longer any excuse for incomplete knowledge. In excellent English, and we have no doubt with faithful adhesion to the original, he has given us more than all of that portion of Kant's work which the author himself considered to be supported by fair demonstrable inferences. This translation, indeed, oversteps the point at which Kant authorised the publication of his work by J. F. Gensichen in 1791. The remaining portion seems to have been too imaginative and fanciful to receive the support of Kant's maturer judgment, but Prof. Hastie has translated the whole, and the part yet unpublished may see the light if a favourable opportunity offers.

Not only has Prof. Hastie given us Kant's views in practically his own words, but by adding a sketch of the theories of other writers of the period, such as Lambert and Wright, and, later, those of Herschel and Laplace, he has reconstructed the environment in which Kant lived, and permitted us to see in some measure the extent of his acquirements and the gradual increase of later knowledge. To Wright, indeed, to whom Kant admits his obligations, the translator has rendered an act of justice by giving at very considerable length both the account of his suggestions, as they appeared in the *Hamburgische Freyen Urtheile* for 1751, and De Morgan's comments on Wright's hypothesis. Perhaps there was less reason for dealing at equal length with Lambert and the elder Herschel, but enough is given to permit the relations between these old astronomers to be readily apprehended. The result of the examination of Kant's work, and of the comparison with other writers on the same subject, has manifestly given Prof. Hastie very exalted views of Kant's power and insight; and by the use of various expressions he invites us to declare that "a greater than Newton is here."

> "Newton was too resolutely opposed to hypotheses not directly founded upon empirical facts, and too anxious to keep within the limits of exact calculation, to give reins to his imagination in the physical sphere. But Kant, gifted with a rare combination of empirical observation and speculative thought, was especially equipped with a genius that could grasp and combine the 'two worlds' in one" (p. lxxxvi).

And again—

> "His (Kant) evolutionary theory was thus co-extensive with the Universe, and included all its parts and all its developments. He was thus the precursor in the eighteenth century of Herbert Spencer and Darwin in the nineteenth; but he was greater than both in that he established the general principles of which they have only given particular expressions" (p. lxxxvii).

Laplace also fares badly at Prof. Hastie's discriminating hands –

> "Kant, indeed, does not write with the admirable lucidity and ease of Laplace, but he has greater strength, more intensity, richer poetic vision" (p. cvii).

We doubt if this generous view of Kant's powers will meet with a ready assent from many readers. But every one will give him credit for the possession and development of one great thought. He saw and appreciated more clearly than any who had lived before him that the creation of the Universe was the result of a process, and not of an act or succession of acts, implying breaches of continuity. He unfalteringly demanded the banishment of all supernatural interferences from the ordered development of nature, and perceived the possibility of deriving the most complicated forms from the universal laws of motion regulating the simplest elements of matter. To rise above the trammels of dogmatic theology, and to give scientific expression to the evolutional processes of nature, were remarkable feats in his age and in the condition of physical science, and much may be forgiven him if in some of his details he shows a lack of accuracy, or if some of his conceptions are in formal contradiction with the principles of mechanics. And his reputation will still stand high if we freely admit that there are errors, or at least inconsistencies, in his cosmogony. There is a tendency in the very able introduction of Prof. Hastie to explain away these errors, and to contend for a closer agreement between the views of Kant and modern scientific theories than really exists. This treatment seems to us injudicious, and tends to raise a spirit of contradiction which really detracts from the very high estimate any one must form of Kant, simply considered by his work in the physical sciences.

Kant's announcement of the appearance of his cosmogony is found in a paper which he wrote, discussing a possible alteration in the time of the earth's axial rotation. We doubt if anything like justice has been done to Kant's memory in connection with this discussion. He there pointed out, in the clearest possible manner, two important facts which in recent times have received very considerable attention, and the early mention of which by Kant discloses a far-reaching apprehension of the operations of celestial mechanism. One is the view revived by Delaunay at the time of the controversy concerning the amount of the secular acceleration of the moon's motion, that the action of the tides must tend to diminish the time of the earth's rotation. The other is, that the explanation of the fact that the moon, in revolving round the earth, turns to it always the same hemisphere, can be traced to tidal influence. But if these two bold speculations have not met with the attention to which they are entitled, Kant himself was not a little to blame for this neglect. For he subsequently adopted the notion that the daily rotation of the earth was accelerated by the falling of heavy particles from the solid crust of the earth towards the centre, supposed to be fluid, and such particles carrying with them a greater velocity of rotation than the lighter particles which might be ascending from the centre. It is, perhaps, of no great consequence to point out here that modern analysis tends to the conclusion that our globe is solid throughout, but it is not a little curious to notice that Kant did not seem to apprehend that the introduction of a second hypothesis does not in any way affect the validity of the former argument. The possibility of the two causes operating together, and the ultimate effect depending upon the amount of their difference, does not seem to have occurred to him. But the paper as it stands in the text betrays a feverish, unphilosophical hurry. The argument is marred by misdescriptions that would have been eliminated by the exercise of more care, and one might well doubt whether Kant fully appreciated the importance of his own suggestions.

But in the presentation of his cosmogony, properly so-called, he lavished all the care and skill of which he was master. Laplace hid his suggestion of the nebular hypothesis away at the end of a volume as though he were ashamed of it, or was afraid that the introduction of more or less hypothetical matter might damage the effect of his rigorous demonstrations. Kant, on the other hand, believing that he was writing a classic for all time—perhaps he was—felt himself entitled to dedicate his work to his sovereign, and was content to base his reputation on the legitimacy of his hypotheses and the use he made of them. But mankind has, perversely enough, connected the nebular hypothesis with the name of Laplace rather than with that of Kant.

To Thomas Wright, of Durham, the author, according to Prof. G. H. Darwin, of a book of preternatural dulness, Kant is indebted for his general view of the construction and arrangement of the Milky Way. Whatever merit or originality the "grindstone theory" possesses, the credit of its discovery seems to be undoubtedly due to this author, and the additions that Kant attached to the description are not particularly happy. For he not only regarded the nebulæ as presenting distant views of remote galaxies and constellative systems in which the construction of our Milky Way was repeated, but he created a central sun about which each star had its appointed orbit, and around which it would run its course during endless ages. We cannot, therefore, follow Prof. Hastie in his assertion that Kant "improved and simplified Wright's theory, giving it a more exact scientific expression" (p. lxviii). Nor are we prepared to admit that "spectroscopic results are so far in entire harmony with Kant's view, and have only extended its range and certainty" (p. c). Spectroscopic observation has not supported the conclusion that nebulæ are due to the combined light of distant suns, so remote that the light from them, condensed into a small space, is visible to us as a tiny luminous cloud. In this place it is sufficient to refer either to the philosophic views held by Schiaparelli, or the more complete examination of these bodies of which an account has been given by Sir Norman Lockyer. Nor is it probable that the stars, collected as they are into irregular clusters or masses with comparatively vacant spaces between them, constitute a stable system. There is no evidence of the existence of a central body of vastly greater mass than the stars surrounding it, which is almost an essential feature to the maintenance of such a system.

But it may be urged that Kant's greatest success is to be found in his construction of the solar system. In the bold conception

> "I assume that all the material of which the globes belonging to our solar system—all the planets and comets—consist, at the beginning of all things was decomposed into its primary elements and filled the whole space of the universe in which the bodies formed out of it now revolve" (p. 74),

he anticipated Laplace in the essential portion of the nebular hypothesis, and though his conception is marred by one great dynamical error, yet possibly his origin of the cosmos comes nearest to that at present held by the greatest authorities. If Kant's theory be maintained in detail it would seem to lead, not to a planetary system, such as at present exists, but to a central sun formed by the collection of all the matter in the "meteoritic plenum." But this may be a quite possible condition at one stage of the process, just as Laplace's hot rotating nebula, with which his hypothesis starts, may represent a later stage. For Lord Kelvin is understood to trace the solar system to an originally

> "cold nebula consisting of separate atoms or of meteoric stones initially possessed of a resultant moment of momentum equal to that of the solar system. Collision at the centre will reduce them to a vapour, which then expanding far beyond Neptune's orbit will give a nebula such as Laplace postulates."[1]

But Kant's great error consists in the assumption that a motion of rotation could be produced from a state of rest by repulsive forces acting upon the rarer masses of the condensing matter, which would give rise to a whirling motion. This is to ignore the fact that the sum total of rotatory motion in a system can never be increased or diminished by the mutual action of its separate parts.

It is needless to dwell on such points as the suspected increase of eccentricity in planetary orbits with increase of distance from the sun, or the explanation offered for the varying densities of the planets with the variations of the radius vector. An effort to bring into quantitative correlation such constants as density, eccentricity, or inclinations of axis, must end in failure for Kant. He will be judged, not by details, but on the general principle by which he claimed to have arrived at a just comprehension of a complete cosmogony. Similarly, one may pass over his genesis of satellites and the formation of Saturn's ring. Of the former it is sufficient to say that both Kant and Laplace saw in the existence of satellites the repetition on a small scale of the formation of the solar system. We know now the extreme probability that the moon owes its existence to a quite unique arrangement, and it would be hazardous to affirm that any one process has been operative in more than one planet. With regard to the latter, if the existence of a ring about Saturn is suggestive of the manner in which planets came into existence, neither Kant nor Laplace could give sufficient reasons to account for the stable condition of the ring in that system and the instability in others.

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[1] G. F. Becker, "Kant as a Natural Philosopher," *American Journal of Science*, vol. v., February 1898.

The problem of the ordered solar system is one around which much future controversy will arise, and possibly the ambition of neither the astronomer nor the physicist will go further than to suggest how it might have been effected on a plan that does not contradict any known physical laws or inferences. This is very different from saying how it actually "rose out of chaos." Prof. Hastie quotes with approval a remark of Kant, "that it is more difficult to explain the genesis of a caterpillar than the origin of a world." If this be true, it may be due to the fact that we know less about the fabric of the Universe than of the caterpillar, and it is consequently easier to be convicted of error in the smaller than in the greater matter. Kant, together with all makers of cosmogonies, enjoys the advantage that the accuracy of the theories cannot be submitted to any adequate test.

W. E. P.

THE HERPETOLOGY OF NORTH AMERICA.

The Crocodilians, Lizards, and Snakes of North America. By E. D. Cope. Reprinted from the Report of the U.S. National Museum for 1898, pp. 153-1270. With woodcuts and 36 plates. (Washington, 1900.)

THE eminent position held by the late Prof. Cope among workers on the taxonomy of vertebrates in the latter half of the past century is chiefly due to the fact that, as has been the case with Prof. Gegenbaur in the field of comparative anatomy, he applied the teachings of the evolutionary theory from the very outset, at a time when other zoologists, imbued with the Cuvierian and Müllerian principles, were still striving at natural arrangements on physiological bases. The ideas set forth in the revolutionary essays on the classification of Batrachians and Lizards, by which he first made his name known, though at first received with little favour by his fellow-workers in Europe, have gradually made their way, and may be said to have well stood the test of time. Although considerably modified in many points both by himself and by others in the intervening thirty-five years, Cope's views hold the field to a greater extent than those of any other taxonomist of the same period. Later in his career, similar attempts at the general classification of Reptiles and Fishes have, in the opinion of the reviewer, been equally successful.

The quick perception of the importance of apparently trivial anatomical details, the veritable instinct with which he realised their phylogenetic bearing and selected them for the purpose of connecting forms widely remote in the systems of his predecessors, and led to conclusions which have, in many instances, ultimately been confirmed by palæontological discoveries, have rendered his name famous in Europe as well as in America. During the later years of his life, however, hasty and careless work, a constant striving at originality, to a certain extent marred the productions of his never-ceasing activity. This may be said of his latest attempts at improving the classification of the Lizards and Snakes, the results of which are incorporated in the thick volume of over 1100 pages now issued by the Smithsonian Institution. It is not stated by whom the work has been seen through the press, nor whether and to what extent the original MS. has been touched up, an omission through which it appears uncertain whether the late author or the editor is responsible for various startling errors which one feels disinclined to ascribe to the former.

The present volume forms part of a series of monographs intended to illustrate the cold-blooded lung-breathers of North America, a work which was devised many years ago by the late Prof. Baird, whose MS. and a number of carefully-drawn figures were placed in the hands of Prof. Cope in 1864. The Batrachians appeared in 1889, the Chelonians were to have been described by Prof. Baur, whose death so nearly followed that of the author of the present treatise, dealing with the remaining orders, viz., *Loricata* (Crocodiles) and *Squamata* (Lizards and Snakes).

As regards the first of these two orders, which includes only two North American living types, *Alligator mississippiensis* and *Crocodilus americanus*, it seems surprising that so advanced a reformer of classification should still have adhered to the inclusion of the *Parasuchia* among the Crocodilians. These Triassic types differ in so many respects from the later *Eusuchia*, and have so much in common with the Rhynchocephalians and the Sauropodous Dinosaurs, that their separation as a distinct order (*Thecodontia*) appears imperative if exact definitions of the allied groups are to be attempted.

Prof. Cope's arrangement by which the *Lacertilia*, or *Sauria* as he prefers to call them, and *Ophidia*, forming the bulk of the fauna, are brigaded under *Squamata* is well in accordance with the present state of knowledge, the supposed characters on which the two groups were formerly allowed ordinal rank being quite insufficient for that purpose. But, in the opinion of the reviewer, a classification in which the *Rhiptoglossa* (Chameleons) are regarded as a mere super-family of Lizards, equivalent with the *Pachyglossa* (*Agamidae*, *Iguanidae*), *Nyctisaura* (*Geckonidae*, *Eublepharidae*), *Uroplatoidea*, *Thecaglossa* (*Varanidae*), *Helodermatoidea*, *Diploglossa* (*Zonuridae*, *Pygopodidae*, *Anguidae*, *Xenosauridae*), *Leptoglossa* (*Teïidae*, *Xantusiidae*, *Lacertidae*, *Gerrhosauridae*, *Scincidae*, *Acontiidae*, *Dibamidae*, *Anelytropidae*), *Annielloidea* and *Annulati* (*Amphisbaenidae*), absolutely fails to express the degree of relationship between them and the members of other families; and if one turns to the synopsis on pp. 200 and 201, in which the distinctive features of the